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Delhomme, II et al.

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[54] **OIL-FREE COMPRESSOR USING SPECIAL GEARING ASSEMBLY BETWEEN ENGINE AND COMPRESSOR**

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[51] **Int. Cl.**^{6} **F04B 17/00**; F04B 39/00

[52] **U.S. Cl.** **417/312**; 417/313; 417/234; 417/364; 181/204

[58] **Field of Search** 417/364, 312, 417/313, 234; 181/200, 202, 204

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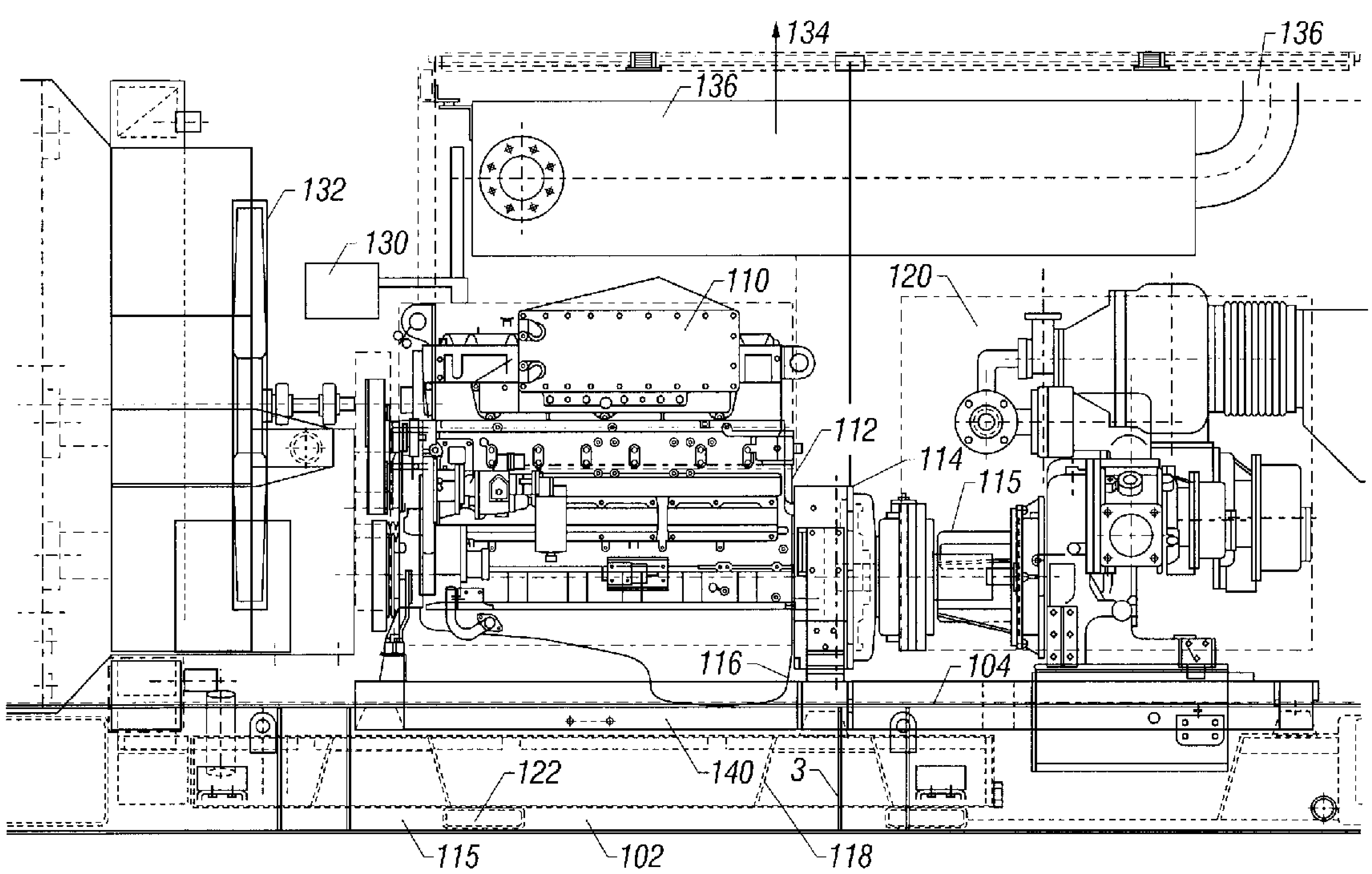
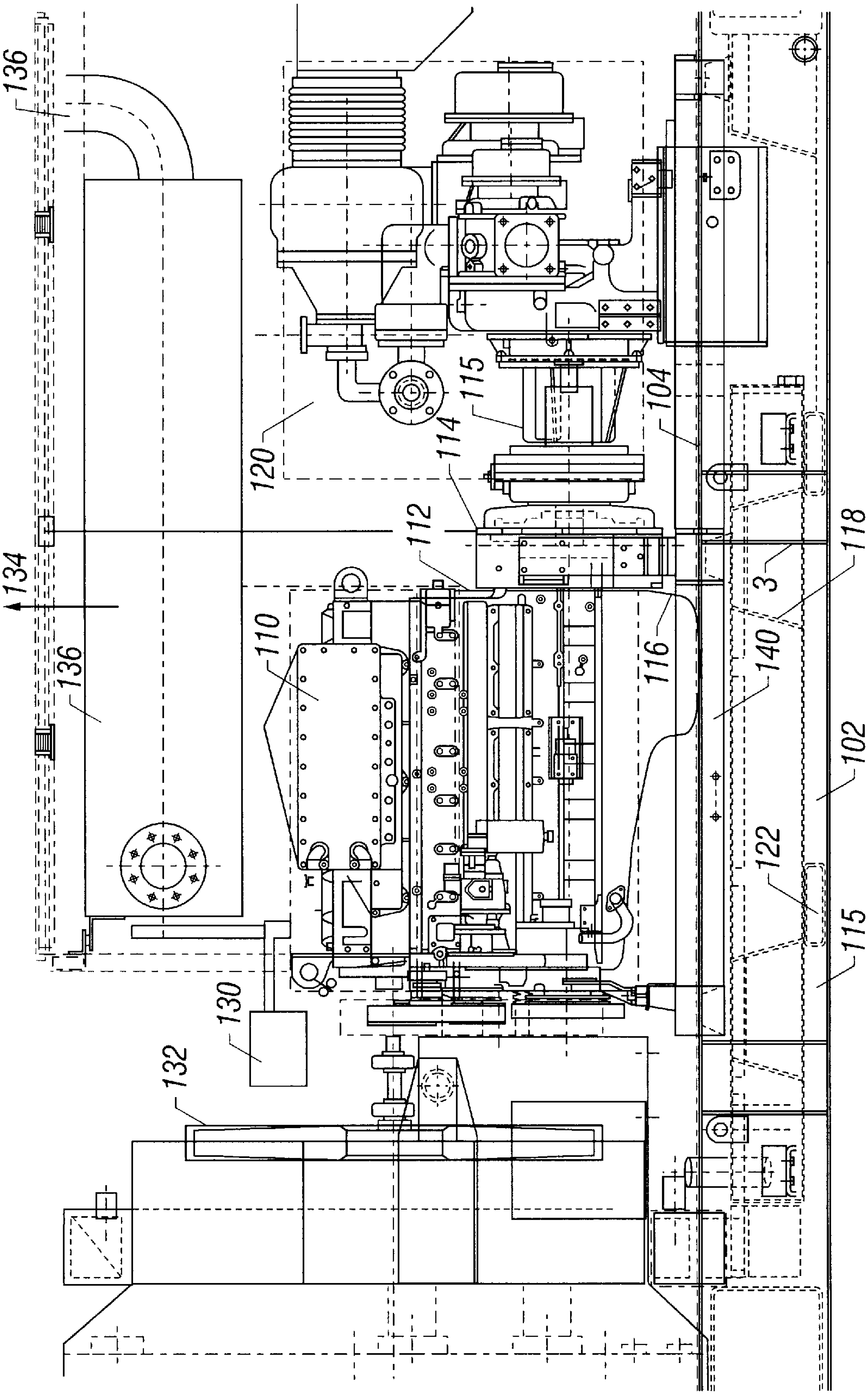
Attorney, Agent, or Firm—Fish & Richardson P.C.

[57] **ABSTRACT**

An oil free compressor uses special structure to interface the engine and compressor. Special quieting structure is also disclosed, including an upward exhaust mechanism, to maintain quiet operation.

18 Claims, 5 Drawing Sheets





136
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FIG. 1

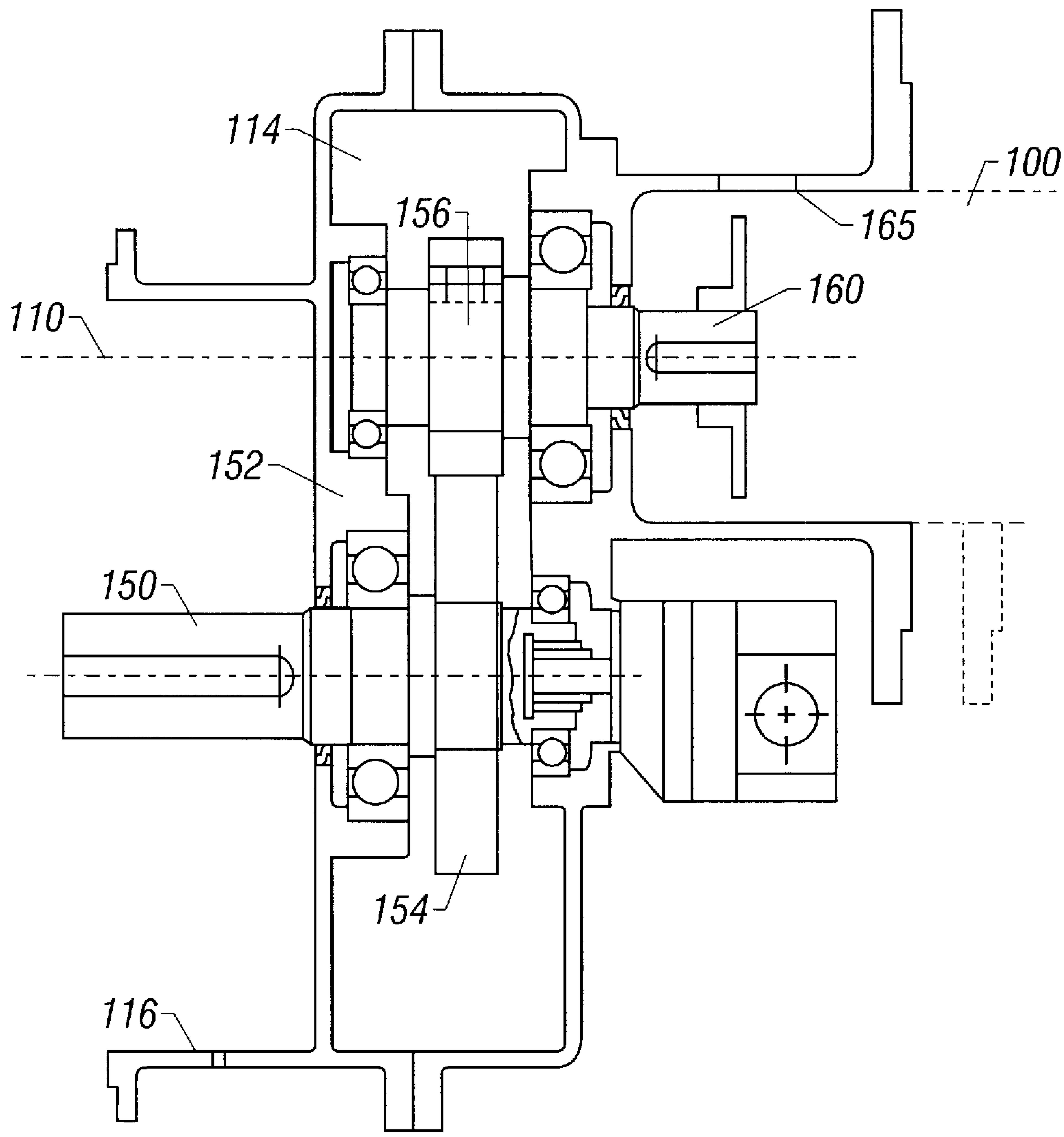
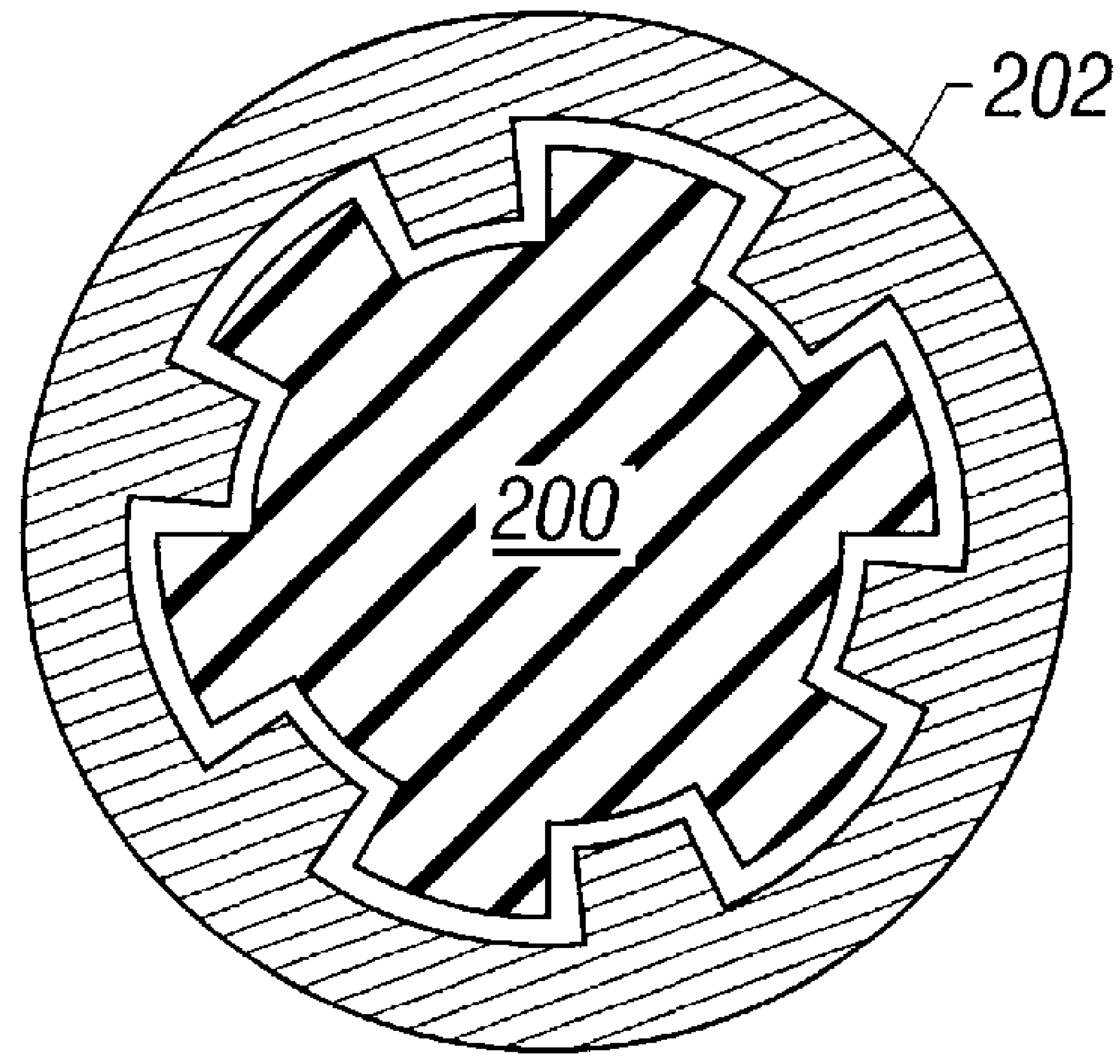


FIG. 1A

FIG. 2A



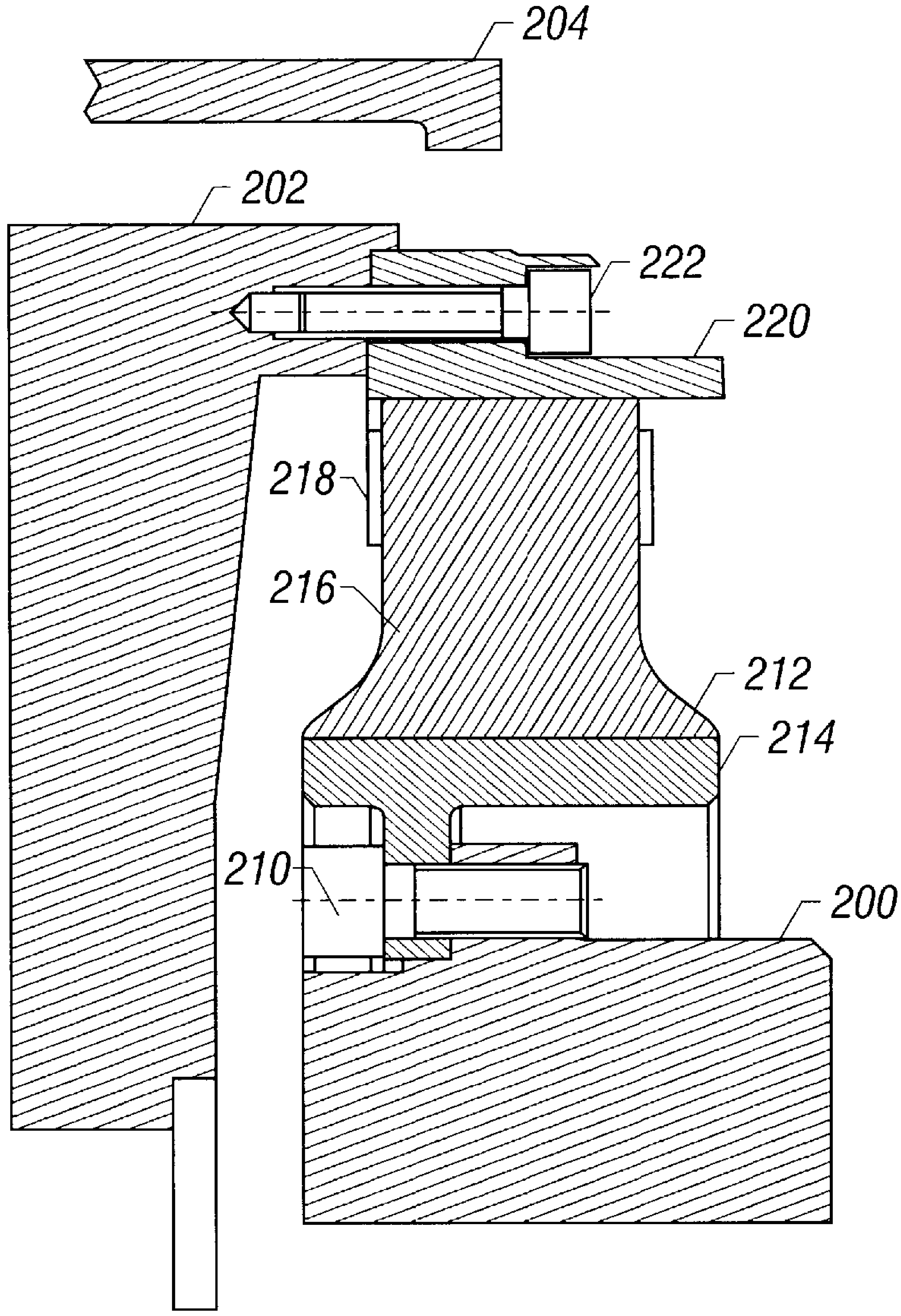


FIG. 2B

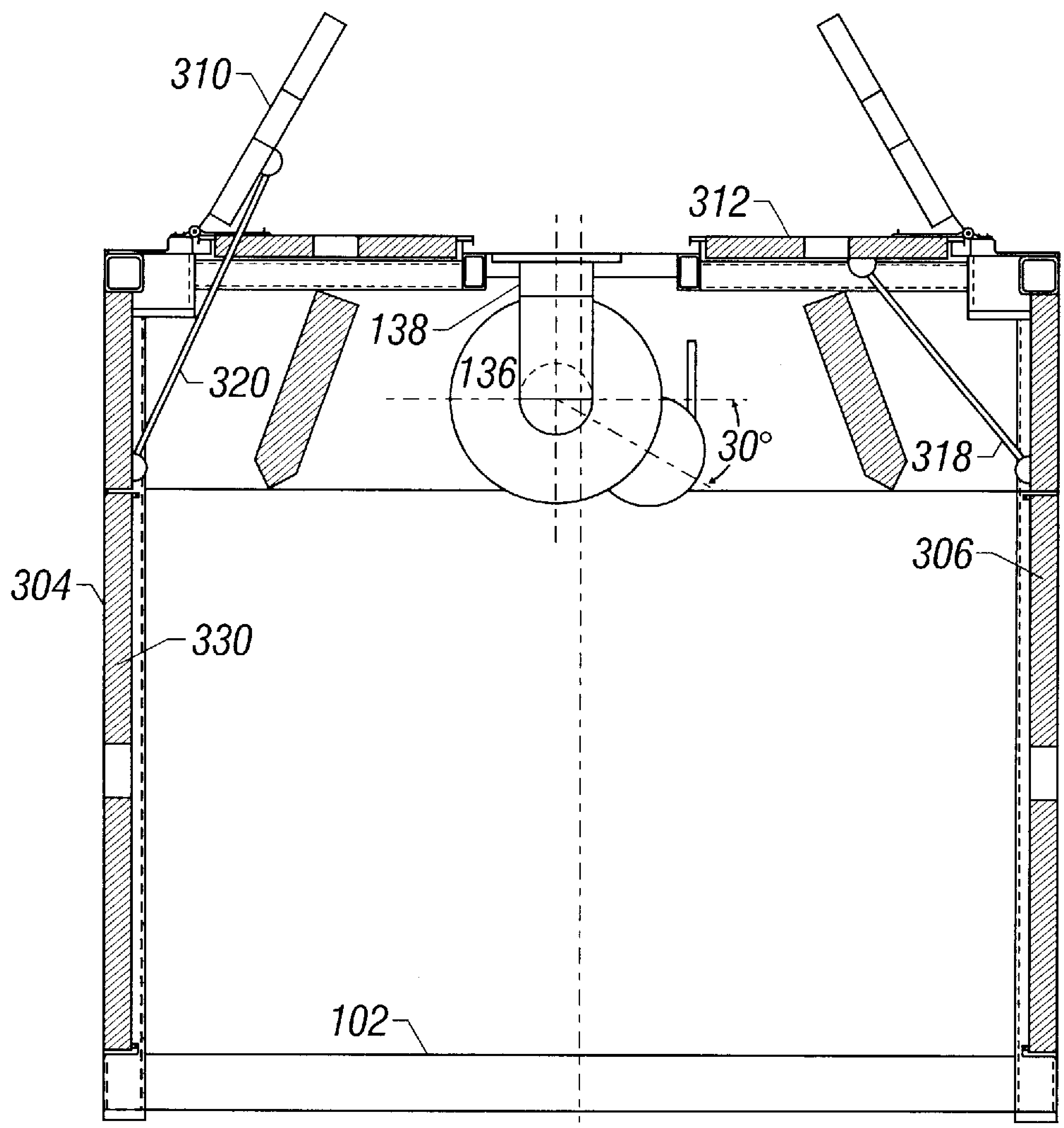


FIG. 3

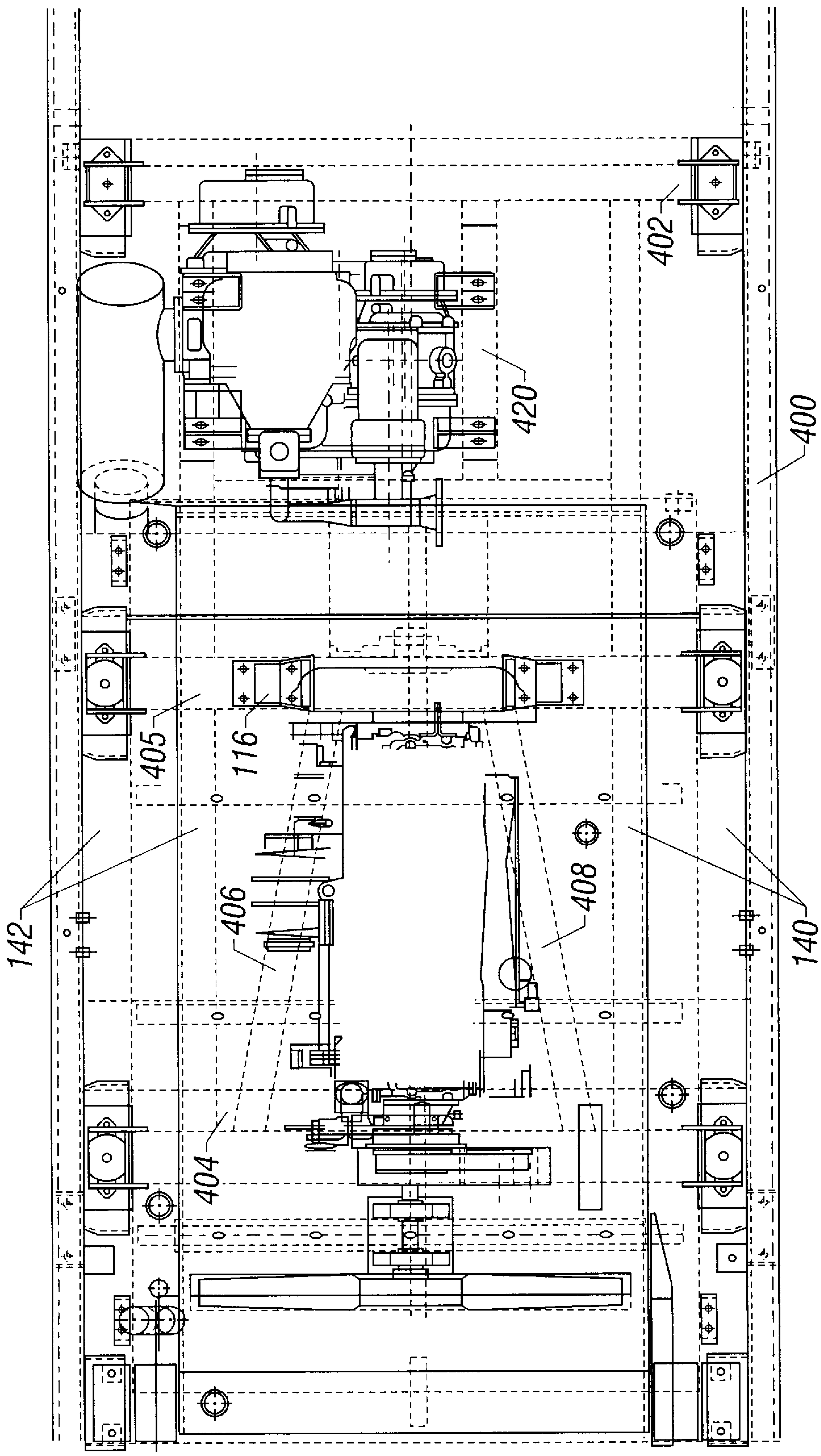


FIG. 4

OIL-FREE COMPRESSOR USING SPECIAL GEARING ASSEMBLY BETWEEN ENGINE AND COMPRESSOR

FIELD OF THE INVENTION

The present invention relates to an oil-free high volume compressor assembly which has reduced noise and improved operating characteristics.

BACKGROUND AND SUMMARY OF THE INVENTION

Air compressors, and specifically high powered air compressors, have well-deserved reputations as oily, dirty and noisy devices. Such compressors often produce large quantities of waste oil in many locations, including in the stream of air that is output from the unit. They have been very loud when operating.

An oil-free output tip for such a compressor has been developed. This device produces an oil-free output; however, this oil-free tip has special requirements. The oil-free tip often requires a relatively high rpm from the driving prime mover. Engines which drive conventional compressor tips often run at 1800 to 2100 rpm. One example of such an engine is made by Kobelko. However, the oil-free tips have often required 3000 or 4000 rpm.

Previous attempts to change the rotational speed of these engines using gears have met with problems. Unexpectedly, many of these attempts at gearing simply did not work, and the inventors found many problems that existed in this gearing. Those problems, and their solutions, are among the objects of the present invention.

Many such compressors, moreover use very loud, noisy prime movers. The inventors also found that the users of these compressors do not want a very noisy or dirty compressor.

Commercial scale compressors of this type operate at extremely high energy levels. The inventors found that any variation in the output of the motor causes extremely difficult problems with balancing and tuning.

It is an object of the present invention to avoid the above-described problems, by providing an oil-free compressor which includes special noise and vibration reducing characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will now be described in detail with reference to the accompanying drawings, wherein:

FIG. **1** shows a cross sectional detail of the engine and compressor as mounted according to the present invention;

FIG. **1**A shows a detail of the preferred gearbox used according to the present invention;

FIG. **2** shows a detailed drawing of the gearing used according to the present invention;

FIG. **3** shows a cross section of the device along the line **3**—**3** in FIG. **1**; and

FIG. **4** shows a top view of the unit of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the invention relates to an oil-free compressor tip and engine which is mounted on a special support mechanism along with its special mechanisms for noise reduction. The mounting and operation is specially modified to take advantage of the special needs of this oil-free compressor.

The support mechanism includes special supports which prevent any harmonic imbalance. As described herein, this support mechanism also includes special elements which minimize noise. The present invention also defines special techniques that the inventors found enable better mounting of this device.

The high speed and power operation of the device requires that the mounting be precisely and carefully controlled. This precise and careful control is extremely important according to the present invention.

The overall compressor mounted unit is shown in cross-section in FIG. **1**. Frame **102** is formed of reinforced steel materials, e.g. ¼ rolled steel. The reinforced materials include an attachment section **104**, which includes surfaces attaching to all of the unit elements. These attached elements include at least the engine **110**, the compressor **120**, and the gearing unit **114**. The output **112** of the engine includes a gearing mechanism **114** which increases the engine RPM by about a 1:1.7 ratio. A special low noise and low vibration gearing system described herein is used for this purpose.

The gearing element **114** includes a first side **115** with an output surface which is a REXNORD coupling press-fit on to the end of compressor **120**. The second side of the gear unit **114** is attached by a flexing structure, e.g., soft rubber connections to the output surface of the engine **110**. One important feature of the present invention is the way in which the compressor and engine are connected to one another. The inventors found that very large stress is created during operation of this system. These stresses inevitably create movement in the most carefully and securely mounted engines. Accordingly, the present invention preferably forms the system without a rigid connection between the engine and compressor. Only one end is rigidly connected; the other end is press fit and allowed to move. This allows movement between the engine and the compressor tip. The gear is rigidly connected to one of the engine or compressor, and connected to the other of the engine or compressor in a non-rigid way. This allows some movement between the engine and compressor without bending or deforming some metal to metal connection.

A detailed structural diagram of the gearing unit as attached to the engine and compressor is shown in FIG. **1**. The diagram shows the gearbox **114** coupled between the engine shaft **150** on the engine side **110**. The other end of gearbox **114** is on the compressor side **120**. Engine **110** rotates to transmit force from the rotation to gear assembly **152**. The gear assembly **152** includes a first gearing part **154** attached to engine shaft **150**, and a second gearing part **156** attached to compressor side shaft **160**. Press fit surfaces **165** are press fit around the outside of the compressor end, to maintain a tight connection therebetween. The press-fit element is also bolted on.

When the inventors first operated this system, they began by simply placing the gear mechanism **114** between the engine **110** and the compressor **120**. They found, however, that the forces created by this operation, and especially the harmonic forces, caused significant problems. Many of the first prototypes that were made were actually destroyed when operated. The inventors solved these problems by certain stiffening of the mounting mechanism **102** and also by careful attachment of the gear casing at **116** to the mounting mechanism. Offset gear elements also allow a certain amount of flexing, and the special flexing structure which are described herein facilitate this flexure.

The compressor mounting mechanism may include inner surfaces **122** which allows the entire connected unit to be picked up by a forklift or other truck mounted connecting element.

The system includes a large number of high-speed and high-stress operating components. The inventors realized that compressor operation and exhaust of cooling air carries much noise. One of the low noise operations of the present invention exhausts all air in an upward direction. This was found to exhaust the noise upwards also. This directional exhaust of air was found to be less bothersome to the user.

The air for cooling the compressor is input through an air intake fan **132** through a noise reducing louver and noise element. The louver preferably includes tilted air deflection elements and a noise filtering material therein. The air that is forced inwards is exhausted upwards through canopy area **134**.

Oil pump **130** produces oil under pressure for use by gear box and compressor components. This oil under pressure is also applied to pressurize canopy pistons **318** and **320**, and hence open the canopy as described herein. Hence, a failure of oil, which can cause many problems, will also cause visual and audial indications: the canopy will close. By closing, the fan will be overloaded, and will cause an unusual noise.

FIG. **2** shows a detail of the gearing attachment system used according to the present invention. The system is conceptually formed of a gear box shaft **200**, and a flywheel **202**. The object of the attachment system is to connect the flywheel to the gear box shaft. The flywheel **202** connects to the crank shaft of the engine. As previously discussed, the flywheel housing **204** forms a bell which is connected to other housing parts to hold the flywheel assembly in its proper place.

Gearbox shaft **200** is connected to the gear box, and provides the output power to the gear box. The gearbox shaft **200** includes bolt **210** which holds the gear box shaft onto the assembly piece **212**. The assembly piece **212** includes a rubber interface plate **214**, a donut shaped rubber plate **216**, rubber connector **218**, and an iron attachment piece **220**. The attachment piece **220** is bolted into the flywheel **202** using bolts **222**.

In operation, the gear box rotates based on power supplied from the flywheel **202**.

An important feature of this aspect of the present invention is that much of the vibration caused by the rotation is absorbed by the rubber elements **216**. This helps silence the operation, but also avoids much of the otherwise possibly harmful vibration which could be caused.

The output noise of the engine is further silenced by muffler **136** which exhausts upward through exit element **138**.

The device main frame **102** includes a lower frame support portion **115** and a connecting portion **140**, by which the engine, compressor, and gear box are supported. Connecting braces **118** connect between the lower portion **115** and the connecting portion. Outer walls are also formed as a housing for the device.

FIG. **3** shows a cross section of the unit along the line **3—3** in FIG. **1**. Side walls **304**, **306** form the sides for the cavity enclosed by the unit. The walls **304**, **306** also include soundproofing insulation **330** therein. Top walls for the unit are formed with openable louvers **310**, **312**. The bottom portion of the housing is also sealed. This forms a sealed housing where the air can only be exhausted upward through the openable louvers.

Each of the louvers is attached to a hydraulic oil-driven cylinder. The oil-driven cylinder **318** is in its minimum size position. In this position, the weight of louver holds down the louver in its closed position shown in **312**. Both oil cylinders, however, are connected to oil pump **130**, which supplies the operating oil for the unit's moving parts. Pressurization of oil by pump **130** expands the hydraulic cylinder to the position shown in by the amount shown in **320**. This expansion overcomes the weight of the louver and presses it upward to the position shown as **310**. In this position, the top is open and the pressurized air can be exhausted upward through the open louvers.

It should be understood that in normal operation there could not be one closed louver and one louver as FIG. **3** shows.

FIG. **3** also shows the muffler unit **136**, and its upward exhausting element **138**. The location of the upward exhaust is preferably between the louvers.

The inventors found that the sound of the unit of the present invention falls into different types many of which are silenced by the system of the present invention. Combustion noise is produced by the operation of the engine, e.g., the explosions caused by combustion of the fuel. The compressor also makes certain noise, "compressor noise". A first part of this noise is carried by the combustion air. This part is quieted both by the muffler, and by exhausting upwards. A second part of the combustion noise is conducted by the steel engine case. This is quieted by the wall insulation, and the flow of air upward which convects the noise upward. A third noise is fan noise for the fan that intakes the cooling air. This noise is quieted by the wall and louver insulations, and by exhausting upward.

This combination of quieting elements produces substantially quieter operation than is possible in the prior art.

All of this is provided to minimize the amount and kinds of sound from reaching the user. Since these devices are typically truck-mounted, the walls are typically at the level of the users' ears. By exhausting the sound upward, the amount of sound that is heard can be minimized.

The bracing of the present invention is extremely important. FIG. **4** shows a top detail of the bracing. The overall housing has a rectangular outer shape of the case for the air compressor assembly. The rectangular case has four insulated walls. However, access panel hatches such as **400** are provided. The long axis of the rectangle includes a first set of supports **140**. The first set of supports include first support **140** and second support **142**. These supports are connected directly to the casing element.

Also connected to that casing element, and between the first set of supports, are longitudinal supports which extend along the short axis of the case. Supports such as **402** extend between the supports **140** and **142** in a direction substantially orthogonal to the supports **140** and **142**, to thus further brace the elements. Extra support elements **406** and **408** extend substantially diagonally between the longitudinal supports **406**, **405**. These diagonal supports provide an additional measure of flex resistance. The usual support members provide support against most kinds of movement. However, the inventors of the present invention found that even slight amounts of movement by the engine can cause undesirable harmonic imbalances. The special diagonal members support between the front and rear of the motor, and prevent many of the otherwise possible motions. Engine

110 is mounted to the frame in various locations. The gear box, moreover, is also securely mounted to the frame at **116**.

The compressor is similarly mounted to frame elements **420 421**.

The long axes of the element may include access covers therein, which enable the device to be opened to secure access thereto. However, the bottom of the housing is preferably totally sealed. The only air intake is through one of the sidewalls, and being exhausted though the top. Sealing the bottom helps not only with noise, for also with cleanliness of the area surrounding the unit by minimizing the amount of oil that is. This has the tendency to make the ground underneath the compressor become very dirty.

Although only a few embodiments have been described in detail above, those having ordinary skill in the art will certainly understand that many modifications are possible in the preferred embodiment without departing from the teachings thereof. For example, while the intake for the cooling air has been recited as being intake from the sidewalls, it could also be intake from the bottom, for example.

All such modifications are intended to be encompassed within the following claims.

What is claimed is:

1. An oil-free compressor assembly, comprising:

a housing for the compressor, said housing including a lower frame defining a bottom portion of the housing, of a substantially rectangular shape, four side walls defining the rectangular shape of the housing, and a top portion, said bottom portion of the housing defining a fluid tight area, underneath said frame, said side walls including soundproofing elements thereon, and said top portion including an openable canopy, whereby sound is exhausted through the top portion only during normal operation, said frame including mounting sections therein;

an engine, mounted to one of said mounting sections of said frame, at least at front and rear portions thereof;

a compressor, mounted to said mounting section; and

a gearing assembly, coupled between said engine and said compressor.

2. An oil-free compressor assembly, comprising:

a housing including a lower frame defining a bottom portion of the housing, side walls, and an upper area;

an engine;

a gearing element, connected to said engine;

a compressor, coupled to said gearing element to receive driving power from rotation of said engine;

at least one-of said engine and said compressor being rigidly mounted to said frame, and the other of said engine and compressor being loosely mounted to said frame to allow movement of said other relative to said frame; and

at least one noise reduction element, coupled to said housing.

3. An oil free compressor assembly as in claim **2**, wherein said engine is rigidly mounted to the frame, and said compressor is press-fit to the engine.

4. A compressor as in claim **3** wherein said gearing element includes flexing structure therein which allows said compressor to flex in direction-relative to said engine.

5. A compressor as in claim **3**, wherein the engine includes output surfaces, and the gearing element includes matching output surfaces which allow a press fit connection to the output surfaces of the engine.

6. A compressor as in claim **3**, wherein said noise reduction element comprises an upward-exhaust mechanism, which causes all waste air from the device to be exhausted in an upward direction.

7. A compressor as in claim **6**, further comprising a noise reducing louver including tilted air deflection elements and a noise filtering material therein, and a fan drawing air inward through said louver, and outward through said upward direction.

8. A compressor as in claim **6**, further comprising an oil pump, producing a pressurized flow of oil, and wherein said housing further comprises a hinged element, which is normally closed, and which is movable to an upward position where it allows air to exhaust upwardly, said hinged element including a piston which is driven by said pressurized flow of oil.

9. An oil-free compressor assembly, comprising:

a housing for the compressor, said housing including a lower frame defining a bottom portion of the housing, four side walls, each connected to said bottom portion, said bottom portion of the housing defining a fluid tight area, said side walls including inner surfaces with soundproofing elements thereon, and at least one of said bottom portion and sidewalls including an air opening with an air louver, said housing also including a movable top portion which is movable between a normally closed position, and an openable position;

an engine, mounted to one of said mounting sections of said frame, at least at front and back portions thereof,

a compressor, mounted to said housing;

an engine, mounted to one of said mounting sections of said frame, at least at front and back portions thereof,

an oil pump, producing pressurized oil for said engine;

an opener for said top portion, driven to open said top portion based on said pressurized oil; and

an air exhaust fan, drawing air in through said air opening and exhausting said air only through said top portion.

10. An oil-free compressor assembly, comprising:

a housing including a lower frame defining a bottom portion of the housing, side walls, and an upper area;

an engine;

a gearing element, connected to said engine;

a compressor, coupled to said gearing element to receive driving power from rotation of said engine;

said engine and said compressor being non-rigidly connected to one another in a way such that angular movement between said engine and said compressor is permitted; and

at least one noise reduction element, coupled to said housing.

11. A compressor as in claim **10**, wherein said gearing element includes a flexible element therein.

12. A compressor as in claim **11**, wherein said noise reduction element comprises an upward-exhaust mechanism, which causes all waste air from the device to be exhausted in an upward direction.

13. A compressor as in claim **12**, further comprising a noise reducing louver including tilted air deflection elements and a noise filtering material therein, and a fan drawing air inward through said louver, and outward through said upward direction.

14. A compressor as in claim **13**, further comprising an oil pump, producing a pressurized flow of oil, and wherein said housing further comprises a hinged element, which is normally closed, and which is movable to an upward position where it allows air to exhaust upwardly, said hinged element including a piston which is driven by said pressurized flow of oil.

15. An oil-free compressor assembly, comprising:

a housing for the compressor, said housing including a frame defining a bottom portion of the housing, side walls defining outer portions of the housing, and a top portion, said bottom portion of the housing defining a fluid tight area, coupled to said frame, said side walls including soundproofing elements thereon, said frame including mounting sections therein;

an engine, mounted to one of said mounting sections of said frame, said engine outputting rotary power at a first predetermined revolutions per minute;

an oil-free compressor, mounted to one of said mounting sections of said frame, and requiring rotary power for its operation, said oil-free compressor operating at a second predetermined revolutions per minute which is different than said first predetermined revolutions per minute; and

a gearing assembly, coupled between said engine and said compressor, said gearing assembly converting said rotary power from said engine to said rotary power for operation by said compressor, and connected to allow relative movement between said engine and compressor.

16. An assembly as in claim **15** wherein a ratio between said first and second predetermined number of revolutions per minute is 1:1.7.

17. An assembly as in claim **15** wherein said gearing assembly is rigidly coupled to one of said engine and said compressor and is movably coupled to the other of said engine and said compressor.

18. An assembly as in claim **17**, wherein said gearing assembly is connected to said frame.

* * * * *